Comparing the weathering of soil and sedimentary palygorskite in the rhizosphere zone

Shiva Bakhshandeh a, Farhad Khormali a,b, Esmael Dordipour a, Mohsen Olamaei a, Martin Kehl b

a Dept. of Soil Science, College of Agriculture, Gorgan University of Agricultural Sciences and Natural Resources, Gorgan, Iran
b Institutes for Geography, University of Cologne, Albertus-Magnus-Platz, 50932 Cologne, Germany

1. Introduction

Palygorskite and sepiolite are clay minerals found specifically in arid regions and form the group of fibrous clay minerals. The structure of palygorskite was first proposed by Bradley (1940), who described a theoretical formula of \([\text{Si}_8\text{Mg}_5\text{O}_{20}(\text{OH})_2]_2(\text{H}_2\text{O})_4\cdot 4\text{H}_2\text{O}\). Fibrous clay minerals have been found to be widespread in late Cenozoic sediments of arid and semi-arid regions of Iran. Three ideal conditions for palygorskite formation in soils and sediments of central Iran are: (1) an increase in the Mg/Ca ratio due to gypsum crystallization in the shallow water bodies; (2) neutral or alkaline pH due to warm climate; and (3) increasing soluble Si due to enriched hydrothermal solutions (Khademi and Mermut, 1998).

Until now, few studies have investigated the origin and the environmental conditions for the stability of these clays (e.g. Akbulut and Kadir, 2003; Bigham et al., 1980; Bouza et al., 2007; Daoudi, 2004; Torres-Ruiz et al., 1994). Little research has so far been done to understand the role of plant roots and the associated microorganisms in rhizosphere soils on the transformation and dissolution of palygorskite (Khademi and Arocena, 2008).

The percentage of palygorskite in soils is related to the gypsum content and the ratio of mean annual precipitation to mean annual reference crop evaportranspiration \((P/ET^*)\) (Khormali and Ahtabi, 2003). Palygorskite and sepiolite are generally believed to weather to other silicate clays, such as smectites may dissolve out of the soil profile when mean annual precipitation exceeds 300 mm (Neaman and Singer, 2004; Singer and Norrish, 1974).

The rhizosphere, defined as the volume of soil influenced by root activity, differs in many aspects from the bulk soil due to root uptake of water and nutrients and to root exudates, root respiration and higher microbial activities. Evidence of the profound chemical changes that occur in the rhizosphere has been reviewed by several authors in...